

WHAT IS CLAIMED IS:

- 1                   1.       A method of etching a noble metal layer disposed on a substrate  
2 comprising the steps of:
  - 3                   a)       providing a substrate supporting a barrier layer, a noble  
4 metal layer on said barrier layer, a protective layer on said noble metal layer, a mask layer  
5 on said protective layer, and a patterned resist layer on said mask layer;
  - 6                   b)       etching a portion of said mask layer including employing a  
7 plasma of a mask etchant gas to break through and to remove said portion of said mask  
8 layer from said protective layer to expose part of said protective layer and to produce said  
9 substrate supporting said barrier layer, said noble metal layer on said barrier layer, said  
10 protective layer on said noble metal layer, a residual mask layer on said protective layer,  
11 and said patterned resist layer on said residual mask layer;
  - 12                   c)       removing said patterned resist layer from said residual mask  
13 layer of step (b) to produce said substrate supporting said barrier layer, said noble metal  
14 layer on said barrier layer, said protective layer on said noble metal layer, and said  
15 residual mask layer on said protective layer;
  - 16                   d)       etching said exposed part of said protective layer to expose  
17 part of said noble metal layer and to produce said substrate supporting said barrier layer,  
18 and said noble metal layer on said barrier layer, a residual protective layer on said noble  
19 metal layer, and said residual mask layer on said residual protective layer;
  - 20                   e)       heating said substrate of step (d) to a temperature greater  
21 than about 150°C;
  - 22                   f)       etching said exposed part of said noble metal layer of step  
23 (d) including employing a plasma of an etchant gas selected from the group consisting of  
24 a halogen containing gas, a noble gas, nitrogen, oxygen, and mixtures thereof, to produce  
25 said substrate supporting said barrier layer, an etched noble metal layer on said barrier  
26 layer, said residual protective layer on said etched noble metal layer, and said residual  
27 mask layer on said residual protective layer;
  - 28                   g)       removing said residual mask layer from said residual  
29 protective layer to produce said substrate supporting said barrier layer, said etched noble  
30 metal layer on said barrier layer, and said residual protective layer on said etched noble  
31 metal layer; and

32 h) etching a portion of said barrier layer including employing  
33 a plasma of a barrier etchant gas to expose part of the substrate to produce said substrate  
34 supporting a residual barrier layer, said etched noble metal layer on said residual barrier  
35 layer, and said residual protective layer on said etched noble metal layer.

3 BPSG, a low dielectric constant material with a dielectric constant less than about 3.0,  
4 and mixtures thereof.

1 10. The method of Claim 1 wherein said barrier layer comprises a  
2 compound selected from the group consisting of TiN, TiSiN, Ti, WN, TaN, TaSiN, Ta,  
3 and mixtures thereof.

1 11. The method of Claim 1 wherein said protective layer comprises a  
2 compound selected from the group consisting of TiN, TiSiN, Ti, WN, TaN, TaSiN, Ta,  
3 and mixtures thereof.

1 12. The method of Claim 1 wherein said mask layer has a thickness  
2 ranging from about 6000Å to about 9,000Å.

1 13. A method of etching a noble metal layer disposed on a substrate  
2 comprising the steps of:

3 a) providing a substrate supporting a barrier layer, a noble  
4 metal layer on said barrier layer, a mask layer on said noble metal layer, and a patterned  
5 resist layer on said mask layer;

6 b) etching a portion of said mask layer including employing a  
7 plasma of a mask etchant gas to break through and to remove said portion of said mask  
8 layer from said noble metal layer to expose part of said noble metal layer and to produce  
9 said substrate supporting said barrier layer, said noble metal layer on said barrier layer, a  
10 residual mask layer on said noble metal layer, and said patterned resist layer on said  
11 residual mask layer;

12 c) removing said patterned resist layer from said residual mask  
13 layer of step (b) to produce said substrate supporting said barrier layer, said noble metal  
14 layer on said barrier layer, and said residual mask layer on said noble metal layer;

15 d) heating said substrate of step (c) to a temperature greater  
16 than about 150°C;

17 e) etching said exposed part of said noble metal layer of step  
18 (c) including employing a plasma of an etchant gas selected from the group consisting of  
19 a halogen containing gas, a noble gas, nitrogen, oxygen, and mixtures thereof, to produce  
20 said substrate supporting said barrier layer, an etched noble metal layer on said barrier  
21 layer, and said residual mask layer on said etched noble metal layer;

22 f) removing said residual mask layer from said etched noble  
23 metal layer to produce said substrate supporting said barrier layer and said etched noble  
24 metal layer on said barrier layer; and

25 g) etching a portion of said barrier layer including employing  
26 a plasma of a barrier etchant gas to expose part of the substrate to produce said substrate  
27 supporting a residual barrier layer and said etched noble metal layer on said residual  
28 barrier layer.

1                           14.     A method of etching a noble metal layer disposed on a substrate  
2     comprising the steps of:

3 a) providing a substrate supporting a barrier layer, a noble  
4 metal layer on said barrier layer, a protective layer on said noble metal layer, a mask layer  
5 on said protective layer, and a patterned resist layer on said mask layer;

12 c) removing said patterned resist layer from said residual mask  
13 layer of step (b) to produce said substrate supporting said barrier layer, said noble metal  
14 layer on said barrier layer, said protective layer on said noble metal layer, and said  
15 residual mask layer on said protective layer;

16 d) etching said exposed part of said protective layer to expose  
17 part of said noble metal layer and to produce said substrate supporting said barrier layer,  
18 said noble metal layer on said barrier layer, a residual protective layer on said noble metal  
19 layer, said residual mask layer on said residual protective layer, and said patterned resist  
20 layer on said residual mask layer;

21 e) heating said substrate of step (d) to a temperature greater  
22 than about 150°C;

27 layer, said residual protective layer on said etched noble metal layer, and said residual  
28 mask layer on said residual protective layer;

29 g) etching a portion of said barrier layer including employing  
30 a plasma of a barrier etchant gas to expose part of the substrate to produce said substrate  
31 supporting a residual barrier layer, said etched noble metal layer on said residual barrier  
32 layer, said residual protective layer on said etched noble metal layer, and said residual  
33 mask layer on said residual protective layer; and

34 h) removing said residual mask layer from said residual  
35 protective layer to produce said substrate supporting said residual barrier layer, said  
36 etched noble metal layer on said residual barrier layer, and said residual protective layer  
37 on said etched noble metal layer.

1 15. The method of Claim 14 wherein said barrier layer comprises a  
2 compound selected from the group consisting of TiN, TiSiN, Ti, WN, TaN, TaSiN, Ta,  
3 and mixtures thereof.

1 16. The method of Claim 14 wherein said protective layer comprises a  
2 compound selected from the group consisting of TiN, TiSiN, Ti, WN, TaN, TaSiN, Ta,  
3 and mixtures thereof.

1 17. The method of Claim 14 wherein said mask layer has a thickness  
2 ranging from about 6000Å to a about 9,000Å.

1 18. The method of Claim 14 wherein said mask layer comprises a  
2 compound selected from the group consisting of Si<sub>3</sub>N<sub>4</sub>, BSG, PSG, BPSG, a low  
3 dielectric constant material with a dielectric constant of less than about 3.0, and mixtures  
4 thereof.

1 19. A method of etching a noble metal layer disposed on a substrate  
2 comprising the steps of:

3 a) providing a substrate supporting an etch-stop layer, a  
4 barrier layer on said etch-stop layer, a noble metal layer on said barrier layer, a mask  
5 layer on said noble metal layer, and a patterned resist layer on said mask layer;

6 b) etching a portion of said mask layer including employing a  
7 plasma of a mask etchant gas to break through and to remove said portion of said mask  
8 layer from said noble metal layer to expose part of said noble metal layer and to produce

9       said substrate supporting said etch-stop layer, said barrier layer on said etch-stop layer,  
10      said noble metal layer on said barrier layer, a residual mask layer on said noble metal  
11      layer, and said patterned resist layer on said residual mask layer;  
12               c)     removing said patterned resist layer from said residual mask  
13      layer of step (b) to produce said substrate supporting said etch-stop layer, said barrier  
14      layer on said etch-stop layer, said noble metal layer on said barrier layer, and said residual  
15      mask layer on said noble metal layer;  
16               d)     heating said substrate of step (c) to a temperature greater  
17      than about 150°C;  
18               e)     etching said exposed part of said noble metal layer  
19      including employing a plasma of an etchant gas selected from the group consisting of a  
20      halogen containing gas, a noble gas, nitrogen, oxygen, and mixtures thereof, to expose  
21      part of the barrier layer and to produce said substrate supporting said etch-stop layer, said  
22      barrier layer on said etch-stop layer, an etched noble metal layer on said barrier layer, and  
23      said residual mask layer on said etched noble metal layer;  
24               f)     etching said exposed part of said barrier layer to expose part  
25      of said etch-stop layer and to produce said substrate supporting said etch-stop layer, a  
26      residual barrier layer on said etch-stop layer, said etched noble metal layer on said  
27      residual barrier layer, and said residual mask layer on said etched noble metal layer; and  
28               g)     removing said residual mask layer from said etched noble  
29      metal layer to produce said substrate supporting said etch-stop layer, said residual barrier  
30      layer on said etch-stop layer, and said etched noble metal layer on said residual barrier  
31      layer.

1               20.    The method of Claim 19 additionally comprising etching said etch-  
2      stop layer.

1               21.    The method of Claim 19 wherein said mask layer comprises a  
2      compound selected from the group consisting of CVD SiO<sub>2</sub>, TEOS, BSG, PSG, BPSG, a  
3      low dielectric constant material with a dielectric constant of less than about 3.0.

1               22.    A method of etching a noble metal layer disposed on a substrate  
2      comprising the steps of:

3               a)     providing a substrate supporting a barrier layer, a noble  
4      metal layer on said barrier layer, a first mask layer on said noble metal layer, a second

5 mask layer on said first mask layer, and a patterned resist layer on said second mask  
6 layer;

b) etching a portion of said second mask layer including employing a plasma of a mask etchant gas to break through and to remove said portion of said second mask layer from said first mask layer to expose part of said first mask layer and to produce said substrate supporting said barrier layer, said noble metal layer on said barrier layer, said first mask layer on said noble metal layer, a residual second mask layer on said first mask layer, and said patterned resist layer on said residual second mask layer;

c) etching said exposed part of said first mask layer to expose part of said noble metal layer and to produce said substrate supporting said barrier layer, said noble metal layer on said barrier layer, a residual first mask layer on said noble metal layer, said residual second mask layer on said residual first mask layer, and said patterned resist layer on said residual second mask layer;

d) removing said patterned resist layer from said residual second mask layer of step (c) to produce said substrate supporting said barrier layer, said noble metal layer on said barrier layer, and said residual first mask layer on said noble metal layer, and said residual second mask layer on said first residual mask layer;

e) heating said substrate of step (d) to a temperature greater than about 150°C;

f) etching said exposed part of said noble metal layer and said residual second mask layer of step (d) including employing a plasma of an etchant gas selected from the group consisting of a halogen containing gas, a noble gas, nitrogen, oxygen, and mixtures thereof, to produce said substrate supporting said barrier layer, an etched noble metal layer on said barrier layer, and said residual first mask layer on said etched noble metal layer;

g) etching said barrier layer to remove a portion of the barrier layer from said substrate to produce said substrate supporting a residual barrier layer, said etched noble metal layer on said residual barrier layer, and said residual first mask layer on said etched noble metal; and

h) removing said residual first mask layer from said etched noble metal layer to produce said substrate supporting said residual barrier layer, and said etched noble metal layer on said residual barrier layer.

1                   23.    The method of Claim 22 wherein said patterned resist layer is  
2 removed from said residual second mask layer during said etching step (c).

1                   24.    The method of Claim 22 wherein said first mask layer comprises a  
2 compound selected from the group consisting of  $\text{Si}_3\text{N}_4$ , BSG, PSG, BPSG, an organic  
3 polymer, a low dielectric constant material having a dielectric constant of less than about  
4 3.0, and mixtures thereof.

1                   25.    The method of Claim 22 wherein said second mask layer comprises  
2 a compound selected from the group consisting of CVD  $\text{SiO}_2$ , TEOS,  $\text{Si}_3\text{N}_4$ , BSG, PSG,  
3 BPSG, SiC, and mixtures thereof.

1                   26.    The method of Claim 22 wherein said first mask layer has a  
2 thickness ranging from about 3000 $\text{\AA}$  to about 8000 $\text{\AA}$ .

1                   27.    The method of Claim 22 wherein said second mask layer has a  
2 thickness ranging from about 500 $\text{\AA}$  to about 4000 $\text{\AA}$ .

1                   28.    The method of Claim 22 wherein said etching step (g) additionally  
2 comprises etching into said substrate.